INTERACTIVE INFORMATION PROCESSING FOR THE ATMOSPHERIC SCIENCES DIVISION AT NASA's MARSHALL SPACE FLIGHT CENTER

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1. INTRODUCTION

This paper describes the interactive computer resources utilized by the Atmospheric Sciences Division (ASD) at NASA's Marshall Space Flight Center (MSFC). The primary focus here is to describe the overall data processing activities, available computer resources, data management, and software applications. Highlighting its effectiveness as a useful interactive research tool, a demonstration of the ASD computer facility will be given at this conference via remote access to MSFC's mainframe computers using both IBM PC/AT and Apple III microcomputer workstations.

2. PROGRAM OVERVIEW

The Atmospheric Sciences Division is involved in the design, testing, data analysis and research related to new remote sensing instruments for future satellite, aircraft, Spacelab, and space station missions. These activities include the Doppler Lidar System, Lightning Mapper, High Resolution Interferometer Sounder, Geophysical Fluid Flow Cell, Multispectral Atmospheric Mapping Sensor, Space Shuttle Main Engine, Satellite Precipitation and Cloud Engineering, Earth Observation Mission, Advanced Microwave Precipitation Radiometer, and the Mesoscale Analysis and Space Sensor programs.

In conjunction with the above, interactive information processing is employed in the areas of multispectral image processing (visible, infrared, microwave), atmospheric modeling (density, circulation, turbulence, fluid dynamics), data management (doppler lidar, lightning, satellite imagery, solar activity, atmospheric data sets, flight experiment data, etc.), real-time satellite data ingest, interactive data display and analysis, and computational fluid dynamics.

3. COMPUTER RESOURCES

To satisfy evolving data processing requirements, the existing ASD computer facility has continued to be upgraded and its computer resources expanded by integrating interactive microcomputer workstations. Through these workstations, access is provided to the ASD facility, the Engineering Analysis and Data System (EADS), and to other accessible computers.

3.1 ASD Computer System

The existing ASD computer system consists of three primary computers (Hewlett-Packard 1000F, Harris/6, Perkin-Elmer 3200 MPS) and associated peripherals along with IBM PC/AT and APPLE III microcomputer workstations that provide over 30 ASD scientists with a wide range of unique capabilities for processing and displaying data (see Figure 3-1).

The Hewlett-Packard (HP-1000F) is utilized for management of large volumes of conventional and satellite derived meteorological data, analysis and graphical display, and general purpose computing. The HP-1000F system consists of 1.25 Mb of main memory, 575 Mb disk storage, and operates under RTE-6/VM Virtual Memory Operating System with Session Monitor. A hardware configuration of the HP-1000F system is provided in Figure 3-2.

The Harris/6 McIDAS (Man-computer Interactive Data Access System) is connected to the IBM McIDAS system at the Space Science and Engineering Center (SSEC) at the University of Wisconsin-Madison, which allows for convenient access and analysis of real-time data, satellite and conventional research data bases, and provides for graphical display/animation of space image data. The Harris/6 McIDAS system consists of 0.25 Mb of main memory, 320 Mb disk storage, and operates under Modified DMS. A detailed hardware configuration of the Harris/6 McIDAS system is shown in Figure 3-3.

The Perkin-Elmer (P-E 3200 MPS) is utilized primarily for numerical modeling and large number crunching tasks. It is a multiprocessor system consisting of three auxiliary processing units (APU's), 16 Mb of interleaved main memory, 1200 Mb disk storage, and operates under OS/32 Revision 8.1 with Multi-Terminal Monitor (MTM). An array processor (FPS AP-120B) is also attached to this system for off-loading CPU bound jobs. A detailed hardware configuration of the P-E 3200 MPS system is shown in Figure 3-4.

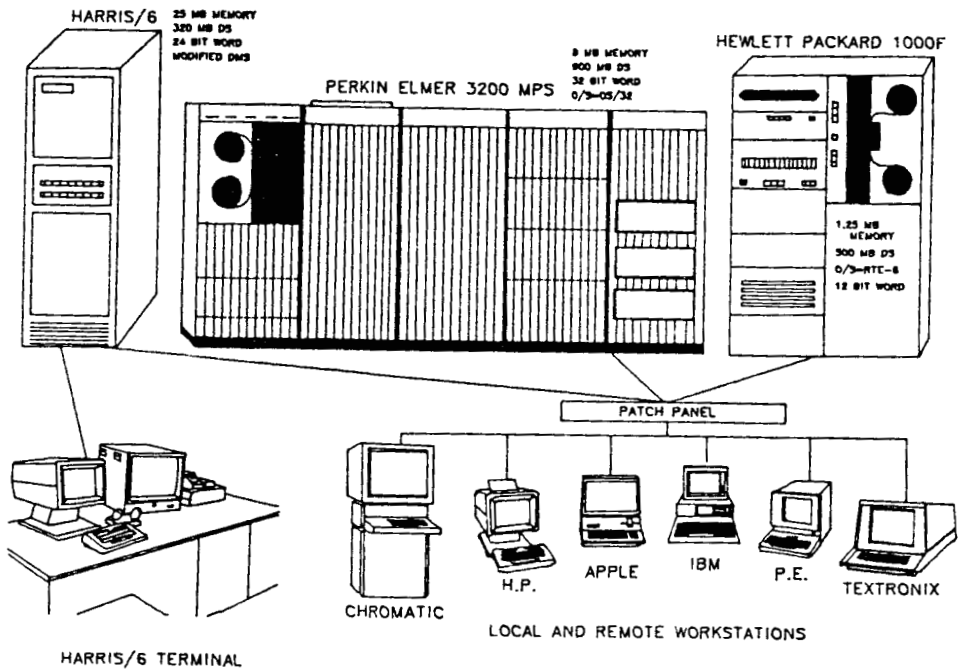

Figure 3-1. ASD Computer System

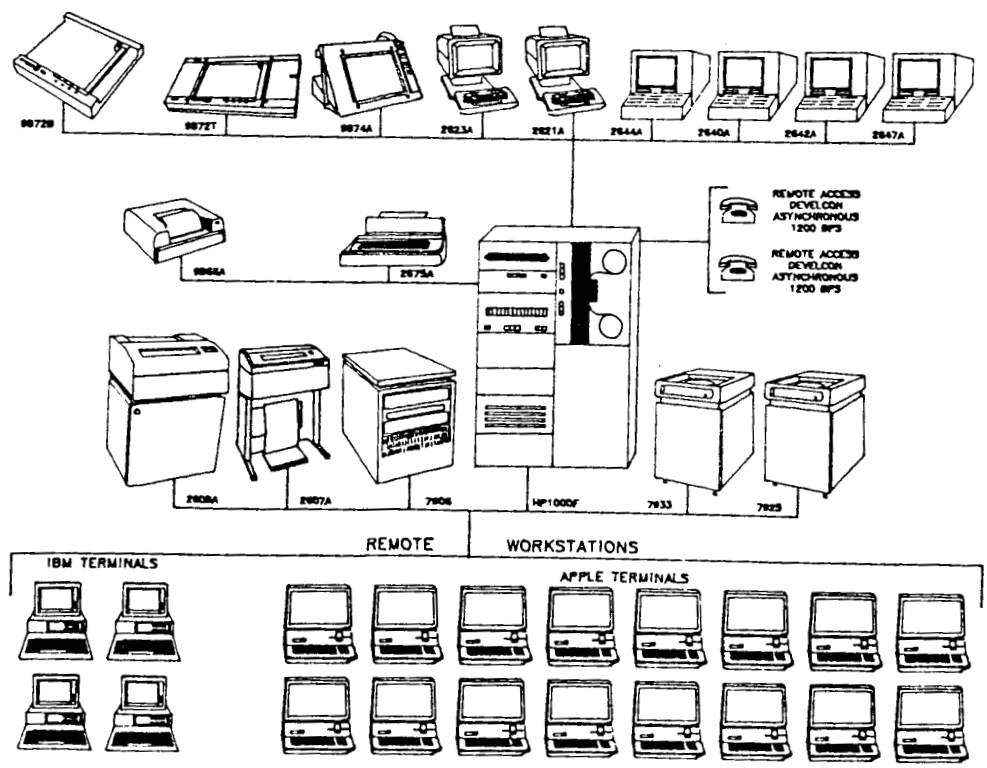

Figure 3-2. Hewlett-Packard 1000F Computer System

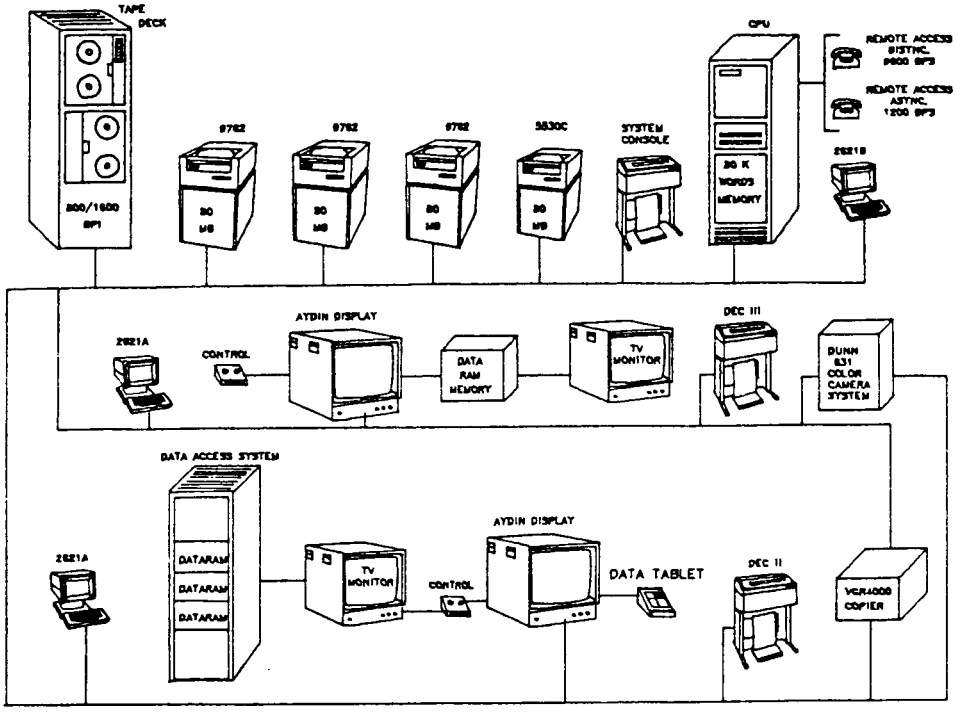

Figure 3-3. Harris/6 Computer System

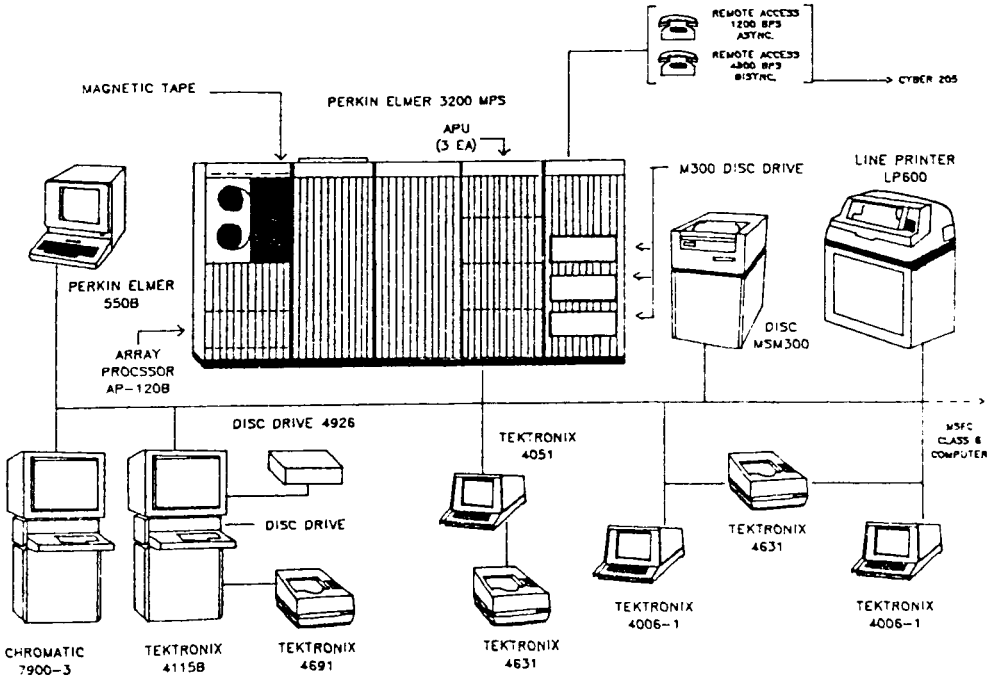

Figure 3-4. Perkin-Elmer 3200 MPS Computer System

3.2 Engineering Analysis & Data System

The EADS is a class six supercomputer facility that is being implemented at MSFC. It consists of a high speed vector processor, a vast amount of memory and on-line storage, monitor and control devices, an interactive terminal subsystem, common output devices, a Local Area Network (LAN) and various graphic software packages. At this time, the EADS is only partially operational with full operations planned for early 1986 (see Figure 3-5).

The High Speed Vector Processor (HSVP) is a CRAY X-MP/44 computer, consisting of four parallel CPU's with 4 megawords of shared memory and dedicated disk storage of 8.4 Gb. The HSVP has an overall performance which is typically ten times that of the CRAY-1. The Front End Processor (FEP) is an IBM 3084 with the MVS/XA operating system and is comprised of two IBM 3081 KX processors, each with 32 Mb memory and 10Gb of dedicated disk storage and 15 Gb of disk storage shared by an IBM 4381-2 processor with 16 Mb memory and 2.5 Gb of dedicated disk storage. These machines are redundantly interconnected in order to avoid a single point of failure.

The IBM 4381-2 is responsible for communications control and image processing. Two IBM 3725 communications controllers handle most of the terminal to host communications. Three image processing workstations are being installed consisting of the following elements: a VAX 11/730 with 2 Mb memory, 456 Mb disk drive, International Imaging Systems (IIS) model 575 hardware and software, Tektronix hardcopy unit, 1/2" and 3/4" broadcast quality VCR's, and a Dunn model 635 camera. One of the image workstations is equipped with an Optronics digitizing camera system as both an input and output device. Emulation software is available to utilize the image workstation as a McIDAS terminal, and further software development will allow image processing capabilities in both McIDAS and IIS modes.

For large amounts of on-line file storage, a MASTOR model M860 unit can store 165 Gb of data on tape cartridges. This system consists of an IBM 4341 computer with several disk drives and is accessible from the FEP and IBM 4381-2.

The EADS network provides various output devices including an NCR 5330 microfilm machine capable of both FR-80 and hardcopy output, two IBM 4248 printers and a XEROX 9700 laser printer, a color film processor to generate movies and viewgraphs, and several other RJE printers and terminals located throughout MSFC.

3.3 Communications

The ASD computer system and EADS can both be accessed from a workstation via a HYBERbus Local Area Network (9600 baud). In addition, selective access to each of the three ASD computers is provided by a 9600 baud ASD fabricated `patch panel' network. The `patch panel' allows up to 60 users to simultaneously route a workstation directly to the desired ASD computer.

Remote interactive access to the ASD computer system and EADS is provided by connecting to MSFC's Develcon data switch via 1200 baud asynchronous RS-232 lines with XON/XOFF protocol. For the ASD system, one port each is connected to the Harris/6 and P-E 3200 MPS. The HP-1000F utilizes the other two lines with the additional option of using ENQ/ACK protocol. Remote access to the EADS is provided through a number of data switch lines into the system.

The HP-1000F supports the DS-1000 communications network which provides for computer to computer data transfer using a dial-up 1200 baud line. The ASD utilizes the DS-1000 network to receive real-time TVA precipitation data for immediate processing and analysis.

The Harris/6 system also provides remote communication through a DDS 9600 baud bisynchronous communication line with the IBM 4381 McIDAS at the SSEC. The line is used as a computer to computer data link to transport case study data sets. These digital and text files can be transferred in either direction along this DDS circuit. In addition, this line is used to directly connect a McIDAS terminal to the SSEC, allowing for real-time support of ASD flight experiments.

The P-E 3200 MPS system offers an RJE connection via a 4800 baud bisynchronous modem driven by HASP protocol. Scientists are using this link to access NASA's Cyber 205 located at Goddard Space Flight Center.

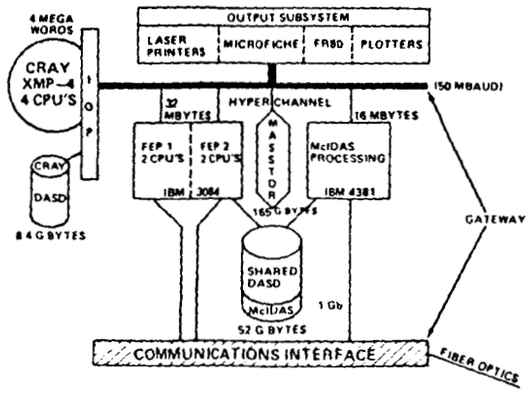

Figure 3-5. EADS System Configuration

3.4 ASD Workstations

The IBM PC/AT and APPLE III microcomputers are being utilized as workstations to allow the ASD scientists to access available NASA/MSFC computers from their office or remotely (see Section 3.3 Communications). A workstation can be connected to one of the three ASD computers, the EADS system, or utilized in a standalone mode, allowing the scientist to interactively analyze and display various data.

The APPLE III workstations are integrated into the ASD system with the following capabilities: 256 Kb memory, letter quality and dot matrix printer, color plotter, color hi-res monitor, B&W monitor, Novation 212A or Hayes Smart Modem (1200 baud), real-time clock, and 5 Mb profile hard disk. Software has been developed to allow the APPLE III workstation to be used as a Hewlett-Packard terminal with graphics capability and future development is underway to emulate the McIDAS graphics terminal. Various software packages are also provided for the APPLE III's to be used in a standalone mode including PASCAL Compiler and APPLE-Writer.

The IBM PC/AT workstations are integrated into the ASD system with the following capabilities: 512 Kb Memory, letter quality and dot matrix printer, IBM enhanced graphics display monitor, and 20 Mb hard disk. Software is being developed to allow the IBM PC/AT workstation to be used as an Hewlett-Packard graphics terminal and a McIDAS graphics terminal. Various software packages are also provided for the IBM PC/AT's to be used in a standalone mode including TURBO PASCAL, dBase III, WORDSTAR 2000, MicroSoft FORTRAN, CROSSTALK, DISPLAWRITE and others.

3.5 McIDAS Terminal

The McIDAS terminal is a specialized meteorological workstation with a number of powerful attributes developed specifically for displaying meteorological satellite and conventional data. A powerful aspect of the McIDAS terminal is its ability to overlay graphics on a satellite image. In this way, plotted or contoured measurements from the field can be visually related via animation capabilities to the satellite image. An additional feature is the red-green stereo display of imagery which allows for three-dimensional display capability. Also, color hardcopies are available using the Dunn 605 camera, black and white hardcopies using the Honeywell visicorder, and video recording using the VCR's.

The terminal consists of a keyboard and CRT monitor with full `video' display, a memory unit, printer, joysticks, and data tablet. The memory device can store 32 image frames, 16 graphic frames and has the capability of expansion with additional memory boards.

Users of the McIDAS terminal may enter their commands from either a standard keyboard or via the data tablet. The joysticks may be used for cursor and color enhancement control. An added capability is that all keys are fully programmable allowing the user to execute a variety of commands with a single keystroke.

4. DATA MANAGEMENT

It is necessary that various experiment data be easily accessible throughout the entire ASD computer system in order to accomplish the required research. Therefore, a few standard formats have been set forth to restructure the in-coming data which arrives from numerous sources and in various formats. Several ASD developed data management utility routines reside on the HP-1000F and are utilized to reformat the data and generate random access disc files on the HP-1000F or magnetic tape output which allows the data to be transferred between the three ASD computers. Figure 4-1 shows the overall data flow throughout the ASD computer system.

There are four basic data types currently being processed on the HP-1000F: Soundings (Rawinsonde, Satellite), Single Level (Surface, Cloud Winds, LLP, Precipitation), Grids (same as Single Level), and Images (Satellite, Radar). The HP-1000F data management software converts the various data and creates a `random access' disk file, thus making the data easily accessible to numerous ASD analysis and display software packages. Associated with each `random access' data file is a "Documentation" file which describes the data set and a "Latitude/Longitude" file which provides information for graphically plotting the station locations. In addition, a "Directory" file exists for each of the data types, which contains the file names, parameter indexes, time periods, dates, titles, and other information.

The Harris/6 offers the scientist a visual means of studying satellite, radar, or conventional data in an integrated manner. All of the data that comes into the McIDAS system is of three basic forms: Images, Grids, and `Station Data Sets' (SDS) files. McIDAS images and grids are rather straight forward, two-dimensional data structures. The SDS structure is one in which there are any number of measurements made at one location at a given time.

Conventional balloon, surface, satellite temperature and moisture soundings, and lightning strokes are examples of data that are put into SDS files. Radar data has been put into both the image and the grid format. Standard objective analysis software routines transform SDS data to the grid structure, usually for the contour applications. The grid can then be put into an image format for display. Transformation in the reverse direction from the image structure to the other structures is usually done with a specialized research goal in mind, and algorithms are quite dependent upon the specific goal.

The P-E 3200 MPS is used to generate vast amounts of data by software which simulates various types of atmospheric phenomenon. Research scientists use this simulated data to correlate their mathematical models to actual data. The model output is stored in contiguous data files which are accessed both randomly and sequentially. NCAR graphics output is stored in `metacode' format which is device independent. Data is easily transferred to and from the P-E 3200 MPS using standard P-E copy utilities.

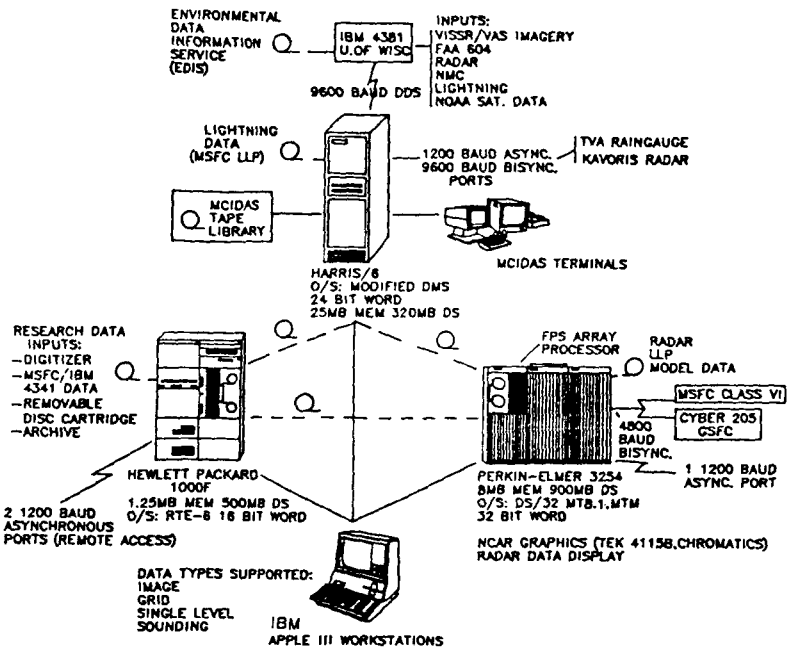

Figure 4-1. ASD System Data Flow

5. ASD SOFTWARE APPLICATIONS

Various application programs and models are executed on a daily basis by scientists utilizing the ASD computer system. Specific applications are performed on the ASD computer that best satisfies the requirements of the program.

The HP-1000F computer system is heavily utilized to analyze and graphically display large volumes of atmospheric data by the use of an interactive analysis and display software package (AVE80). This package is a `menu driven´ set of Fortran programs which process the four basic types of data (Sounding, Single Level, Grid, Image) and generates various outputs based upon the user´s selectivity. By using the AVE80 programs, atmospheric data may be displayed in various forms such as Skew T plots, parameter value and profile plots, station and parameter base map plots, wind vector and wind profile plots, wind barb plots, grid parameter contouring, printed grid profile, shaded printed images, and colored image displays/animation (see Figure 5-1).

The AVE80 program will prompt the user for various interactive inputs for qualifying the desired data options. The user may process data on a single case basis or select multiple cases. The user then may select the desired data parameters such as data type, data base, time periods, station numbers, latitude, longitude, pressure levels, etc. Finally the user may select the output device , line styles, colors and several other options depending on the output desired. Output devices available to the user include: HP X-Y color plotters, HP graphics printer/plotter, HP Thinkjet printer, HP Laser Jet printer, color monitors, and APPLE III and IBM PC/AT workstations.

Several high-level programs exist on the McIDAS to permit application of sophisticated algorithms to image data. One such program uses many images at differing spectral wavelengths to reproduce vertical atmospheric temperature and moisture soundings. Another program uses several images for an animated sequence for the purpose of calculating tracked winds. Rainfall estimation algorithms have been developed which utilize infrared and microwave images. These techniques aid in determining precipitation characteristics over both land and oceans. Figure 5-2 shows example outputs from the McIDAS system.

The P-E 3200 MPS system is used primarily for executing atmospheric physics and fluid dynamics research models of high CPU bound activity. The P-E also supports the NCAR graphics package with metacode translators for Tektronix terminals and FR80 microfiche output. Color graphics capability is available on the Tektronix 4115B and Chromatics terminal, which support the interactive research of the Doppler Radar/Lidar activities, specifically using the NEXRAD software from the National Severe Storms Laboratory.

The atmospheric physics models include the Multispectral Atmospheric Mapping Sensor (MAMS) which measures atmospheric, cloud and surface characteristics at very fine horizontal resolution with spectral imagery (separate visible and infrared spectral bands) to map the 4-D atmospheric temperature, moisture and cloud fields. Other models run on the P-E include the Limited Area Mesoscale Predication System (LAMPS), Pielke´s, Cloud Wind and the South Dakota 2-D cloud model.

Space Shuttle Main Engine (SSME) and Spacelab projects use the P-E system primarily for computational and geophysical fluid dynamics modeling. The scientists execute CHAM´s PHOENICS code which allows them to simulate flows and generate graphics output. Figures 5-3 and 5-4 show example outputs from the P-E system.

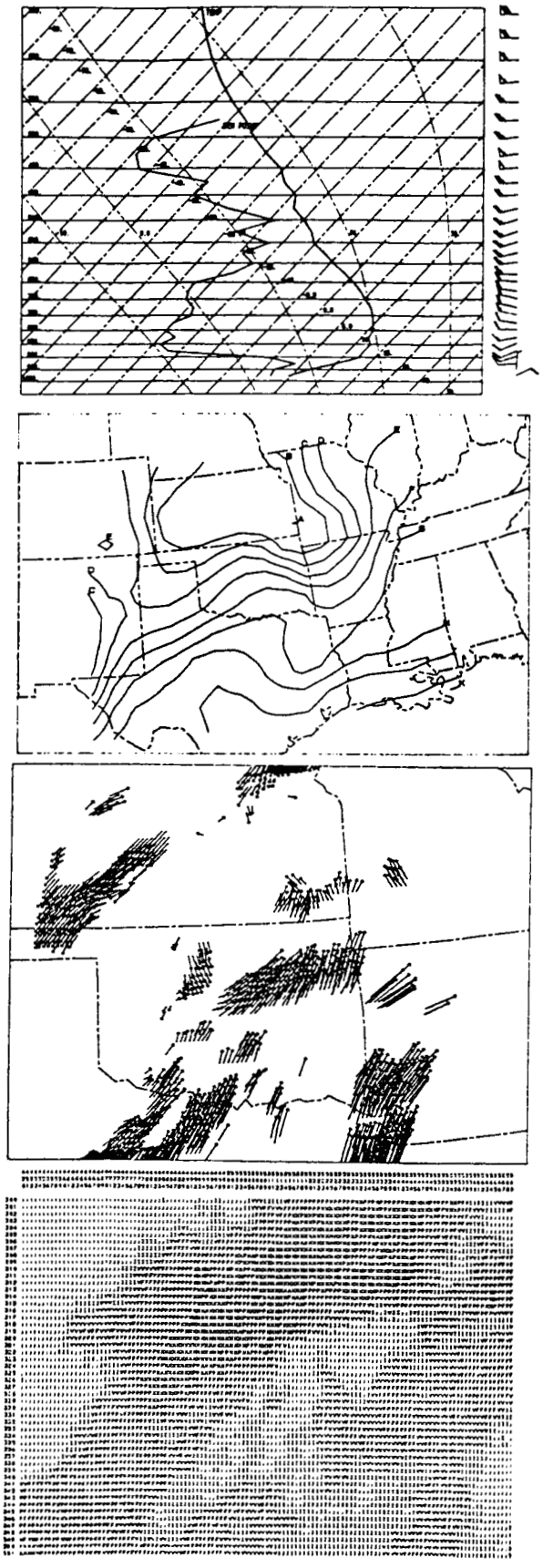

Figure 5-1. HP-1000F AVE80 Program Outputs

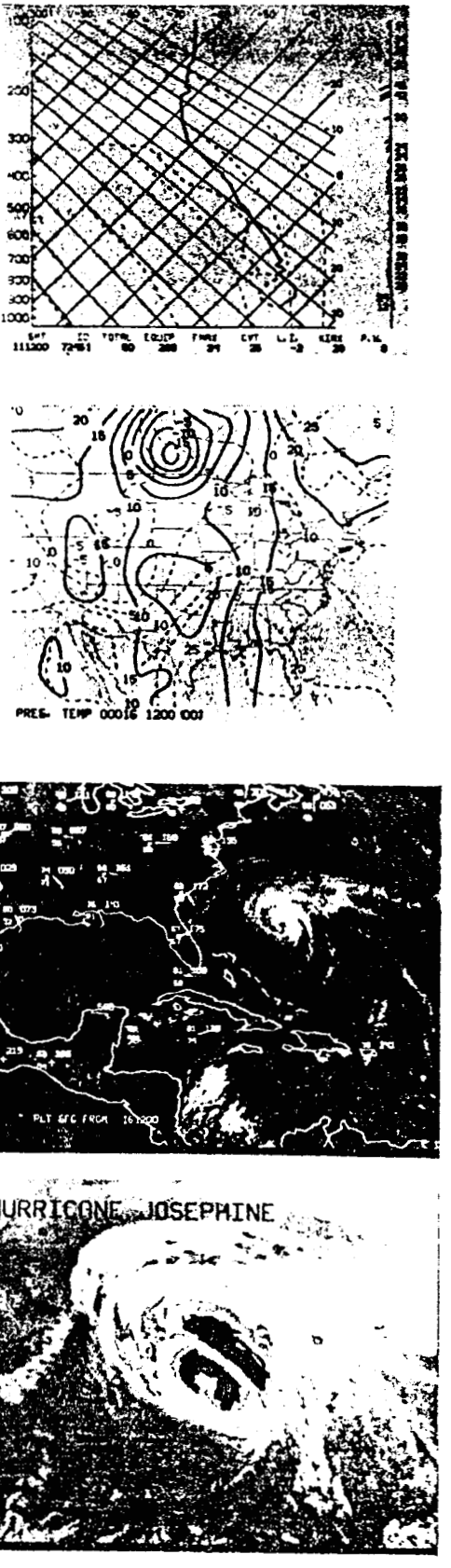

Figure 5-2. Harris/6 McIDAS System Outputs

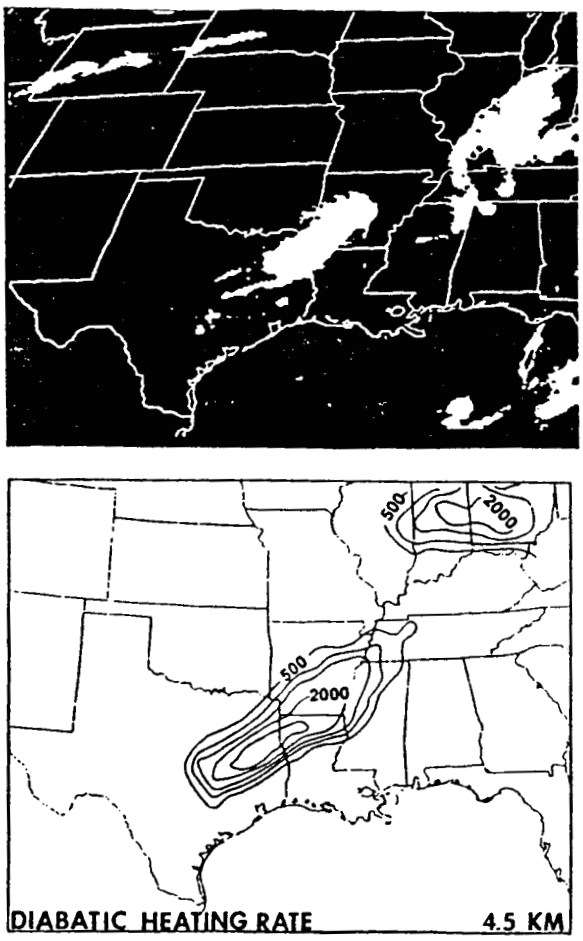

Figure 5-3. P-E 3200 LAMPS Model Output

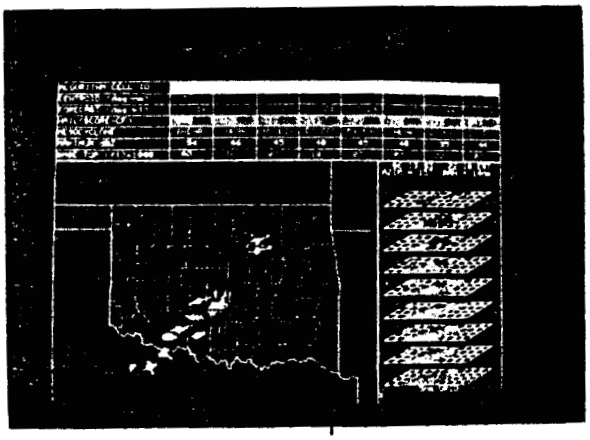

Figure 5-4. P-E 3200 NEXRAD Model Output

6. SUMMARY

In summary, the ASD computing facility provides the research scientists with a complete interactive information processing capability to satisfy its current data processing activities. The ASD system will continue to be upgraded to meet future requirements as well as to enhance capabilities of the system to better meet the needs of the scientists/user. Additional microcomputer workstations will be integrated into the system to allow for even more users to access both the ASD computer system and the EADS class six supercomputer facility.

7. ACKNOWLEDGMENTS

Special thanks go to Mike Kalb, Steve Goodman, Roy Spencer, and Bob Atkinson for the graphical outputs generated from various application software on the ASD computer system. Additional thanks to Norm Reavis for use of the system diagrams which were also generated on the ASD computer system.

8. REFERENCES

Grumman Data Systems Corporation, 1985: EADS User's Guide, 1-2.